



Procedure: C-A-AGS-001-TVDG  
Revision: 04  
Revision Date: 2/23/04

## COLLIDER-ACCELERATOR DEPARTMENT

Title: Tandem Van de Graaff Facility EMS Process Assessment

Preparer: Ray Karol

Group: ESH&Q

### Approvals

\_\_\_\_\_  
*Signature on File*  
Date: \_\_\_\_\_  
ESH&Q Division Head

\_\_\_\_\_  
*Signature on File*  
Date: \_\_\_\_\_  
Collider-Accelerator Department Chairman

(Indicate additional signatures)

Y	N	
x		FS Representative: _____ Date: _____
x		Radiological Control Coordinator: _____ Date: _____
x		Chief ME: _____ Date: _____
x		Chief EE: _____ Date: _____
x		Environmental/P2 Coordinator: _____ Date: _____
x		QA Manager: _____ Date: _____
x		Other: _____ Date: _____

**BROOKHAVEN NATIONAL LABORATORY  
PROCESS ASSESSMENT FORM**

**I. General Information**

Process ID:	AGS-001-TVG	PEP ID# 001		
Process Name:	Tandem Van de Graaff Facility			
Process Flow Diagrams:	<a href="#">AGS-001-TVG-01</a> , <a href="#">-02</a> , and <a href="#">-03</a>			
Process Description:	<p>The process assessment includes all industrial operations, which take place within Building 901A in support of the operation of the Tandem Van de Graaff (TVDG), a large electrostatic accelerator facility. The TVDG is used for independent research and industrial irradiation applications as well as to supply ions to the AGS, NSRL and RHIC facilities. In this facility, personnel also conduct light machining operations, chemical processing, and vacuum system equipment maintenance.</p> <p>Applicable Subject Areas include: Hazardous Waste Management, Radioactive Waste Management, Liquid Effluents, Non-Radioactive Airborne Emissions, Radioactive Airborne Emissions and Pollution Prevention.</p>			
Dept./Div.:	Collider-Accelerator Department			
Dept. Code:	C-AD			
Building(s):	901A			
Room(s):				
Point of Contact:	C. Carlson			
Originally Prepared by:	G. Schroeder	Original Reviewers:	C. Carlson G. Goode M. VanEssendelft J. Williams F. Zafonte	
Initial Release Date:	03/01/00			

## II. Detailed Process Descriptions and Waste Determination

The Tandem Van de Graaff (TVDG) Facility, located in Building 901A, provides low energy ion beams to the Alternating Gradient Synchrotron (AGS), National Space Radiation Laboratory (NSRL) and the Relativistic Heavy Ion Collider (RHIC). Light and heavy ion beams are also produced for use within the three active target rooms in Building 901A for technological and industrial applications. The TVDG has been in operation since 1970 and remains one of the world's largest electrostatic accelerator installations. The facility is operated by the Pre-Injectors Group, which is part of the Collider-Accelerator Department.

The TVDG physically consists of two model "MP" electrostatic accelerators, designated MP-6 (see Figure 1) and MP-7. Each accelerator is enclosed within a 11,250 ft<sup>3</sup> pressure vessel containing an insulating gas at an operating pressure of about 12 atmospheres. A horizontal, in-line arrangement allows operation of each machine independently or for the use of MP-6 as an injector for MP-7. Independent or "two stage" operation of the accelerators provides the capability for simultaneous experiments to be carried out in separate target rooms. The coupled, or "three stage" mode makes use of MP-6 as an injector for MP-7, providing beams of higher energy and intensity than are available from either machine alone. Both accelerators can operate at a maximum terminal voltage of 15.5 MV and are capable of high intensity pulsed beam operation.



**Figure 1 Accelerator Room 1 with MP-6 shown in background.**

The Heavy Ion Transport Line, or HITL, was completed in 1986, connecting the TVDG to the AGS, providing fully stripped ions up to mass number 32 to the AGS for fixed target experiments. In 1992, construction of the AGS Booster and the HITL-to-Booster (HTB) line was completed. The complex of HITL and HTB is formally designated the Tandem-to-Booster (TTB). The Booster accepts ions from the TVDG and accelerates them to energies required for experiments at NSRL or for injection into the AGS. Ions that are injected into the AGS ring may

then be directed into the RHIC for the collision of like or different ion species up to 100 GeV/amu (gold) or to Building 912 or the U-line for target collisions.

Examples of other TVDG uses include experiments by a collaboration of scientists from NASA and BNL to conduct a radiobiology research program at NSRL or Building 912 related to the investigation of space radiation on humans. This research is particularly important for the planning of future long-term deep space flights. The TVDG is also used for the study of space radiation effects on materials; in particular, Single Event Upset Testing and spacecraft instrument calibration.

## **Regulatory Determination of Process Outputs**

### **1.0 Target Rooms**

Building 901A houses four separate target rooms designated TR1 through TR4 (though TR1 and TR3 are not currently in use as a target area), with several distinct beam lines available in each room. The target rooms primarily contain beam tubes, vacuum pumps and high voltage power supplies. TR1 is used to test ion sources. TR3 contains power supplies and instrumentation for accelerators and transport lines. There is no routine maintenance required on the HV power supplies and the equipment contains no PCB capacitors; all power supplies are of 1986 vintage or newer. TR2 is used for thin film filter production, a service purchased by outside companies where ultra-pure water is needed in manufacturing processes, such as in the semiconductor industry. Polycarbonate and polyester films are supplied by the customer and irradiated by heavy ions to produce microscopic holes in the film. TR4 houses the Single Effect Upset Test Facility (SEUTF), which is used to test microcircuits in a simulated cosmic ray environment. Again, outside customers purchase the use of this facility. No routine wastes are generated by either of these processes.

Vacuum pumps are used to draw air out of the beam tubes, which could attenuate ions before they reach the intended target. Vacuum pumps are periodically serviced with the replacement of oil, gaskets and o-rings. See Section 5.0 for a discussion of wastes generated by pump maintenance.

Beam line components within target rooms can become activated. Those that are no longer useful are surveyed and disposed of as low-level radioactive waste if activated (1.1). Typically, this is limited to a few small items per year. See process flow diagram [AGS-TVG-001-01](#).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
1.1	Beam line components	Non-hazardous, potentially radioactive / based on radiological survey	Dispose of as scrap metal or LLRW, depending on survey results	None

## 2.0 Control Room



In addition to housing monitoring consoles, the TVDG control room contains a small electrical assembly and maintenance area in the northwest corner of the room. It is basically a workbench with an electrical component storage area. Some bench-top soldering work is done here. If the solder being used contains lead or silver, the tailings are collected for recycling or containerized for recycling (2.1). Scrap wire is disposed of in the regular trash (2.2).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
2.1	Solder tailings	Hazardous if it contains lead or silver / process knowledge	All shops collect tailings in containers and full containers go to Central Shops for recycling	None
2.2	Scrap wire	Non-hazardous solid / process knowledge	Disposed of in regular trash	None

## 3.0 Laboratories

Building 901A contains three laboratory rooms. No industrial or bench-top work is currently being conducted in Lab 1, though some light machining work is conducted in Labs 2 and 3. Lab 3 contains a drill press and an area for bench-top soldering (2.1). Metal fines from the drill press are disposed of in the regular trash (3.1). Depending on the composition of the metals being drilled, these fines could be considered hazardous waste. They are segregated for collection in the scrap metals bin for recycling. See also discussion of Waste ID 4.1.3.



This lab also contains a small blueprint copy machine. The ammonium hydroxide supply for the copier is completely used in the printing process, the only wastes being vapors and empty plastic supply bottles. Lab 2, in addition to containing the equipment for stripper foil development, discussed in Section 3.1, also contains a small drill press, a glove box and a cylinder of compressed argon gas.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
 3.1	Metal fines from drill press	Potentially hazardous / process knowledge	Disposed of in regular trash	None
 3.2	Argon gas	Non-hazardous / process knowledge	Released to ambient air	None

### 3.1 Stripper Foil Development

“Stripper foils” are produced in Lab 2. These foils are used to remove electrons from ions that are accelerated at the Tandem. The foils are held in metal frames and are very small (only a centimeter or two in diameter). The first step in foil production is to prepare a glass plate by applying a release agent made of a hygroscopic salt compound. Elements such as carbon or gold are then uniformly applied to the plate using electrical current and a piece of equipment known as an evaporator. The evaporator uses mechanical and diffusion pumps, each requiring periodic oil changes. The mechanical pumps use standard vacuum pump oil, which is disposed of as described in Section 5.0.

A colloidal solution is then applied to the plate along with distilled water to float the carbon or gold on the glass plate where it can then be transferred to a metal frame. The distilled water, colloidal solution and release agent mixture is released to the sanitary system (3.1.1) and the glass slide is disposed of in the trash (3.1.2). The foil is consumed during its use in the accelerator and the foil frame is reused. The frames are surveyed to assure that there is no activation and, prior to re-use of the frames, they are cleaned with a biodegradable soap in an ultrasonic cleaner. The cleaning process removes any residual carbon remaining on the frames and the resulting cleaning solution is released to the sanitary system. (3.1.3) See process flow diagram [AGS-001-TVG-02](#).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
 3.1.1	Release agent / colloidal solution / distilled water	Non-hazardous / process knowledge	Disposed of in sanitary drain	None
 3.1.2	Glass plates	Non-hazardous / process knowledge	Disposed of in regular trash	None

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
3.1.3	Biodegradable soap / colloidal solution / residual carbon	Non-hazardous / process knowledge	Disposed of in sanitary drain	None


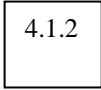
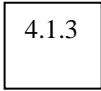
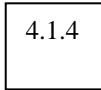

## 4.0 Accelerator Operations

### 4.1 General

The Accelerator Vault holds the MP-6 and MP-7 units. Though the room is not physically divided, the west and east sides are known as Accelerator Rooms 1 and 2, respectively. Most equipment in the vault is electrical, though a number of cryogenic vacuum (or “cryo”) pumps are in the area. Cryo pumps are serviced in the Vacuum Lab (see Section 5.0). Compressed gases stored in the area include helium, which is used for vacuum leak detection and filling the cryo pumps, and nitrogen, which is used to vent vacuum systems. Nitrogen is dryer than air and prevents moisture, which is hard to drive out, from entering the surfaces of vacuum system components. All fugitive gas emissions are released to ambient room (4.1.1). Empty gas cylinders are returned to the manufacturer for reuse (4.1.4).

Some amount of mechanical maintenance is being performed on the accelerators at all times and the Vault contains some light machining equipment such as grinding wheels and drill presses. Part lubrication and cleaning takes place here; ethyl alcohol (4.1.5) is in common use as well as dry spray lubricants like Zeplon. Rags generated by part wiping are disposed of in the regular trash or as industrial waste if saturated with oil (4.1.2). Machining debris is segregated between metals and non-metals and disposed of as scrap metal or thrown in the trash, accordingly (4.1.3). Though activated metals are not routinely produced within the TVDG facility, the metal scrap dumpster is surveyed using a micro-R meter prior to release to verify the lack of measurable contamination. Though it is possible that some of the metals that are machined could contain RCRA-hazardous metals such as chromium, which is contained in stainless steel or lead, which is contained in some brass, this is not of concern if the metals are designated for recycle.

The basement of the accelerator vault, also known as the “pit,” contains power supplies, transformers, and the pumps and dryers for the insulating gas. There has been an extensive effort within the TVDG to replace PCB-containing equipment wherever possible. However, complete replacement of all PCB-bearing components is impractical due to the unique nature of some of the equipment. Process flow diagram [AGS-001-TVG-01](#) captures the waste streams discussed above.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
	Helium and nitrogen gas	Non-hazardous / process knowledge	Released to ambient room air	None
	Used rags	Non-hazardous / process knowledge	Disposed of in regular trash or as industrial waste if saturated with oil	None
	Machining debris	Potentially hazardous, non-radioactive / process knowledge	Metals segregated for recycle and surveyed, all other materials disposed of as trash	None
	Empty compressed gas cylinders	Non-hazardous / process knowledge	Returned to manufacturer for re-use	None
	Ethyl alcohol vapors	Non-hazardous / process knowledge	Released to ambient room air	None




## 4.2 Insulating Gas System

Because of the tremendous voltages produced inside the accelerators, each unit is filled with an insulating gas to prevent electrical arcing. The gas is a mixture composed of 45% SF<sub>6</sub>, 45% N<sub>2</sub>, 5% CO<sub>2</sub>, and 5% O<sub>2</sub>. The mixture is not intentionally released to the atmosphere, as the SF<sub>6</sub> is quite expensive. In fact, the gas is scavenged down to a pressure of 1 torr prior to back-filling the vessel with air to allow for personnel entry. However, the TVDG Safety Assessment Document, (pg. 4-58) estimates that up to 300 ft<sup>3</sup> of SF<sub>6</sub> per year is lost as fugitive emissions (4.2.1). Though a release of insulating gas via an emergency purge system has been reviewed, this small fugitive emission is included in the BNL airborne emission source database. This emission does not require a N.Y. State air permit.

Two compressors and a vacuum pump are used to transfer the insulating gas between the accelerators and the storage facility located on the hill above Building 901A, to the north. The storage facility consists of two buried, opposing banks of high-pressure gas storage cylinders with an intervening concrete structure, which allows access to the piping and valve systems. All



gas entering the accelerators is passed through two activated alumina-drying towers. The alumina is replaced about once every five to ten years. It is surveyed for radioactivity, though it has always been found to be uncontaminated in the past. The alumina is disposed of in the regular trash (4.2.2). The gas system also utilizes roughing filters, which are disposed of in the trash when spent (4.2.3). See process flow diagram [AGS-001-TVG-01](#).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
	SF <sub>6</sub> insulating gas	Non-hazardous / process knowledge	Fugitive release to ambient air	None
	Used activated alumina	Non-hazardous / process knowledge	Disposed of in regular trash	None
	Used roughing filters	Non-hazardous / process knowledge	Disposed of in regular trash	None

### 4.3 Cooling Water

Facility beam-line magnets, power supplies and various beam components, which experience heating during operation, are cooled by a closed loop water system. The water is deionized to minimize undesirable effects that metals can have in the vicinity of strong magnetic fields. The ion exchange system consists of a bag filter and parallel canisters filled with deionizing resin and carbon. Make-up water for the cooling water system is supplied by the BNL potable water system. After use, the deionizing resin and carbon are rendered hazardous due to heavy metal content. Originally, the resin was flushed and regenerated on site, creating approximately 300 gallons of hazardous liquid waste. In an effort to minimize this waste stream, disposable beds are now used. Resin and carbon is removed from the canisters and sent off-site as hazardous waste (along with the bag filters) approximately once every three to five years (4.3.1). Historically, these wastes have not been found to be radioactive.


During accelerator operations with high-energy protons or deuterons, the potential exists for activation products to be formed in the cooling water. If maintenance is performed which requires partial draining of the water system, a sample is submitted for radiological analysis. If uncontaminated and approved by the Environmental and Waste Management Services Division, the drained water is discharged to the sanitary system (previous analysis for metals have been performed which indicate levels which are acceptable for sanitary discharge, TVDG SAD, pg. 4-58) (4.3.2). Note that previous samples have shown no radioactive contamination in this water. See process flow diagram [AGS-001-TVG-01](#).

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
4.3.1	Spent filters, deionizer resin and carbon	Non-radioactive, hazardous / process knowledge, direct analysis	Disposed of as hazardous waste through WMD	None
4.3.2	Water drained from cooling water system	Non-hazardous, non-radioactive / by direct analysis	Released to sanitary system following authorization by ESD	None

#### 4.4 Radioactive Air Emissions



During operations with accelerated protons or deuterons, it is possible that air activation products will be generated in the Accelerator Vault or target rooms. Calculational estimates of the radionuclide types and quantities generated can be found in the facility Safety Assessment Document dated November 1995. That evaluation postulates a very conservative generation rate by assuming acceleration of deuterons to 28 MeV for 40 hours per year. During the FY03 run, deuteron ions at energies up to 18 MeV in the TTB were transferred to the Booster, eventually collided with gold ions at RHIC for about 5 months. Normally, deuteron beam is only utilized in the TVDG Target Rooms for about 20 hours per year, with most operations being performed with heavy ions at lower beam currents and energies than the SAD evaluation assumes. Radionuclides, which could be generated under this scenario, include tritium,  $^7\text{Be}$ ,  $^{41}\text{Ar}$ ,  $^{11}\text{C}$ ,  $^{13}\text{N}$ ,  $^{15}\text{O}$  and  $^{14}\text{O}$ . The total generated source term for each radionuclide is very small, in the range of microcuries to millicuries, annually. An Unreviewed Safety Issue document was generated, reviewed and approved to address all of the safety issues related to the RHIC deuteron run. This showed that air activation at TVDG and TTB was only a small fraction of the emissions from the Booster Applications Facility, thus continuous air monitoring is not required. Any air activation products would be created in the ambient air surrounding beam components, and could thus be released to the atmosphere via the building HVAC system (4.4.1). See process flow diagram [AGS-001-TVG-01](#).

Air activation products generated by the TVDG have not previously been identified as a radioactive air emission source and have not been included in the site annual NESHAPs report to the EPA. Though it is clear from the magnitude of the source terms involved that the potential public dose from this source is negligible, a formal dose evaluation using the CAP88-PC dispersion model was performed by the Environmental and Waste Management Services Division. See Section IV, Assessment, Prevention and Control, for additional compliance recommendations.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
	Fugitive radionuclide air emissions	Radioactive / process knowledge	Released to ambient room air	None

## 5.0 Vacuum Lab

The Vacuum Lab is used for the storage and maintenance of mechanical and cryogenic vacuum pumps. Used mechanical pump oil is sampled for radioactive material, containerized and stored in the 90-Day area located in the Mechanical Equipment Room. This oil is typically not radioactive, permitting its disposal as industrial waste by the Waste Management Division (5.1). As needed, old gaskets and o-rings from mechanical pumps are disposed of in the regular trash (5.2). No significant mechanical work is performed on the cryo pumps; if they fail, they are usually returned to the manufacturer for repair or replacement. They usually require helium replacement only.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
	Used vacuum pump oil	Non-hazardous, non-radioactive / process knowledge, direct analysis	Disposed of as industrial waste through WMD	None
	Used o-rings, gaskets from vacuum pumps	Non-hazardous / process knowledge	Disposed of in regular trash	None

## 6.0 Ion Source Lab

The Ion Source Lab contains a variety of chemical compounds used in the preparation of ion sources and target materials, which are used in the TVDG. All chemicals utilized in Building 901A are tracked using the BNL Chemical Management System (CMS), and can be found at <http://www.esh.bnl.gov/cms/>. Most compounds stored in this lab are target materials based on elements such as titanium, oxygen, bromine, tin, etc.

A typical ion source such as cesium is a solid metal at room temperature. Though no volatile vapors are anticipated, the ion source is loaded into an ionizing “boiler” unit while in a HEPA-filtered hood in the Source Lab. The total quantity used is about two grams. Also, a target holder is loaded with an appropriate solid or powder target material such as gold. The boiler

assembly and target holder are transferred to the Accelerator Vault for insertion into the machine. The boiler heats the cesium metal to the point where cesium ions are released, or “sputtered” from the matrix. From there, they are accelerated by large potential differences towards the target, liberating ions from the target for acceleration into the Tandem to Booster line. The target and ion source are consumed in the process.

After use, the boiler unit is washed using a weak hydrochloric acid solution. Typically, this solution is reused a few times before being discarded. The spent solution is neutralized and released to a sanitary drain (6.0). The total amount of liquid amounts to a few milliliters.

Waste ID	Waste Description	Determination/Basis	Waste Handling	Corrective Action Required
6.0	Hydrochloric acid solution	Non-hazardous, non-radioactive / process knowledge	Neutralized, released to sanitary drain	None

## 7.0 Mechanical Equipment Room / Machine Shop

The Machine Shop and Mechanical Equipment Rooms are separate areas of the same room. The machine shop contains a variety of machining tools including lathes, grinding wheels, table saws, drill presses, angle benders, a bead blaster, metal punch, etc. It is also used for non-flammable compressed gas storage. Materials machined in the shop include plastic, Lucite, some G-10, aluminum, stainless steel, copper, and some brass, though very little. Any metal remnants are segregated for disposal as scrap metal and eventual recycling; all other debris is disposed of in the trash (see Waste ID 4.1.3).

### III. Waste Minimization, Opportunity for Pollution Prevention

During the initial effort of baselining, the Collider-Accelerator Department processes for Pollution Prevention and Waste Minimization Opportunities each waste, effluent and emission was evaluated to determine if there were opportunities to reduce either the volume or toxicity of the waste stream. Consideration was given to substitute raw materials with less toxic or less hazardous materials, process changes, reuse or recycling of materials and/or wastes, and other initiatives. These actions are documented in this section of the original process evaluation. Action taken on each of the Pollution Prevention and Waste Minimization items identified can be found in the Environmental Services Division’s PEP 2000 Database. Further identification of Pollution Prevention and Waste Minimization Opportunities will be made during an annual assessment of C-A processes. If any Pollution Prevention and Waste Minimization Opportunities are identified, they will be forwarded to the Environmental Services Division for tracking through the PEP Database.

#### **IV. Assessment Prevention and Control**

During the initial effort of baselining the Collider-Accelerator Department Assessment, Prevention, and Control (APC) Measures operations, experiments, and waste that have the potential for equipment malfunction, deterioration, or operator error, and discharges or emissions that may cause or lead to releases of hazardous waste or pollutants to the environment or that potentially pose a threat to human health or the environment were described. A thorough assessment of these operations was made to determine if engineering controls were needed to control hazards; where documented standard operating procedures needed to be developed; where routine, objective, self-inspections by department supervision and trained staff needed to be conducted and documented; and where any other vulnerability needed to be further evaluated. These actions are documented in this section of the original process evaluation. Action taken on each of the Assessment, Prevention and Control Measures can be found in the Environmental Services Division's PEP 2000 Database. Further identification of Assessment, Prevention and Control Measures will be made during an annual assessment of C-A processes. If any Assessment, Prevention and Control Measures are identified, they will be forwarded to the Environmental Services Division for tracking through the PEP Database.